

An accurate knowledge of the amount or depth of snow in the high mountains and their foothills, with statements of the condition of the surface of ground when the snow first covered same and additional information as to whether the snow is loose or well packed, will render it possible to predict with considerable accuracy the run-off for the year. It is hoped that the Weather Bureau will be able to secure such data as to the snowfall at a number of stations in high altitudes so that the Reclamation Service may have at hand accurate information on which to regulate the Pathfinder Reservoir to the best advantage.

This regulation of the reservoir will also require a knowledge of the evaporation from the surface of same, and it is hoped that the Weather Bureau and Reclamation Service can cooperate to secure such records.

The Pathfinder Dam and Reservoir are parts of the North Platte Project, of which Mr. Andrew Weiss is Project Engineer and Mr. R. F. Walter, Supervising Engineer.

#### PROTECTION OF FRUITS FROM FROST, ETC.

Letter from the Secretary of the Missouri State Board of Horticulture to the Section Director at Columbia, Mo., and remarks by the latter.

I heartily agree with you that there ought to be close cooperation between the Weather Service and the various Departments of Agriculture. I certainly hope that in the near future it will be possible for the Weather Bureau to make a careful study of the reasons for crop failures, particularly fruit, in certain regions. In Missouri certain sections, for no apparent reasons based on topography or isotherms, nearly always escape injury. I particularly have in mind the famous peach region about the town of Koshkonong in Oregon County. As usual, that section suffered no injury from the blizzard of mid-April. The peaches at Koshkonong were absolutely unharmed. The peach district there extends a short way into Howell County, but I think not farther than Brandsville, as I know practically all of the fruit was destroyed in the northern and western parts of Howell County. This specially favored district seems to extend east into Ripley County, at least at Doniphan there was very little injury from the blizzard of April 24. However, at this place the fruits were badly winterkilled, whereas at Koshkonong there was no winter injury. However, I should explain that even in the vicinity of Koshkonong poorly kept orchards, or those located in low ground were injured by the cold weather of the winter.

The value of knowing the definite reasons why Koshkonong is such a favored place for fruit growing lies in the fact that there may be other regions just as good as the one spoken of; also if we knew why Koshkonong is favored above other places we might be in a position to give definite advice about the location of orchards in many parts of the State which have not been tried and, perhaps, on theoretical grounds, we might be able to forestall failures which are inevitable, owing to certain natural conditions of topography, physiography, temperature, etc.

It may not be possible to secure any definite information along the line I have mentioned without having a number of volunteer observers in and around the special districts to be studied. If it were feasible to undertake certain "climate surveys" of this kind, some very interesting statistics, I feel sure, would be quickly forthcoming.

Another line of work in which the fruit grower must look to the Weather Bureau for assistance is the matter of frost warnings in connection with the heating of orchards. Orchard heating is a new thing in this State and by no means old in other States. The great difficulty now in the way of heating orchards economically is that the growers either do not know the exact time at which to light their heaters, or being somewhat uncertain about the matter, become excited or, whatever the case may be, they light the fires too soon. In many instances the temperature does not fall quite low enough to make it

necessary to light the fires, but not knowing the danger point within a matter of 2° or 3°, a great deal of fuel may be consumed unnecessarily. Under such circumstances the grower finds that his neighbor who did not heat his orchard had just as much fruit as he did, and so loses faith. We have determined the exact temperatures representing the danger point at the different stages of development of fruit from the time the buds are dormant to the time the young fruit is of considerable size. It seems to me that it might be quite possible for the Weather Bureau to warn fruit growers, even in remote districts, of frosts and freezes in ample time for them to get everything ready for heating their orchards.

REMARKS BY GEORGE REEDER, SECTION DIRECTOR, IN CHARGE OF THE MISSOURI SECTION, U. S. WEATHER BUREAU.

The suggestion of Professor Howard that the Weather Bureau make careful study of the temperature effects in connection with the fruit crop with a view of ascertaining, if possible, why some localities appear to be more immune from killing frosts than other near-by regions is, while not new, an interesting one, and if followed out might lead to some valuable information that would be useful to the fruit grower.

The climatological records of southern Missouri probably cover too short a period of time to enable one to form a correct opinion as to whether Koshkonong lies within a "thermal belt" or "verdant zone." The data that we have however indicate that the locality in question is not appreciably more favored as regards weather changes than its neighbors.

Table 1 gives the average date of the last killing frost in spring, the latest date on which a temperature of 32° F. occurred, and the number of times that freezing temperatures occurred as late as May, at all stations in the southern tier of counties situated in about the same latitude as Koshkonong, from McDonald County on the west to Ripley County on the east, a strip of country averaging about 25 miles wide and 200 miles long.

TABLE 1.

County.	Station.	Latitude, north.	Longitude, west.	Elevation.	Record, years.	Average date of last killing frost in spring.	Latest date on which 32° F. occurred.	Year.	Number of times 32° F. occurred as late as May.
McDonald	Dean*	36 39	94 21	1000	12	Apr. 21	May 5	1906	3
Barry	Mineral Springs†	36 41	93 48	1475	12	Apr. 15	May 20	1894	2
Taney	Protem†	36 32	92 52	1000	5	Apr. 20	May 4	1903	1
Howell	Olden	36 50	91 54	1248	17	Apr. 16	May 9	1906	2
Oregon	Koshkonong	36 36	91 38	911	10	Apr. 16	May 1	1903	1
Ripley	Doniphan	36 37	90 49	440	7	Apr. 19	May 2	1909	1

\*Near Anderson, P. O. †Closed in 1905. ‡Closed in 1906.

We find from the foregoing table that the section of the country extending from Koshkonong, and probably some little distance westward of that town, eastward to Doniphan, has but a slight advantage over the sections more to the northward and westward. The average date of the last killing frost in spring at Olden and Koshkonong (the latter being 20 miles farther south) is the same for 17 and 10 years, respectively. Freezing temperature has occurred at Olden as late as May, twice in 17 years, and once at Koshkonong in 10 years. It is true that a freeze occurred at a later date at Olden than at Koshkonong, but that can be accounted for by the difference in latitude and elevation. Similar differences at stations farther west may be accounted for in the same manner, including longitude, as the western part of the State is usually colder than the eastern part when averages are considered. In other words, the climatic factors in the region between Koshkonong and Doniphan do not vary more than one would expect for the latitude and topography.

The apparent immunity of orchards in this region, especially in the neighborhood of Koshkonong, from damaging tempera-

tures in the spring, is probably due to *local air drainage* (the cold air being drained away from the orchards), and the care given the orchards. To support the point made that the air drainage forms a large part of the protection, one has but to examine the columns headed "Latest date on which 32° F. occurred as late as May" and "Year," in Table 1. It will be seen that the dates of the month, as well as the years, are different for different stations. For instance, a freeze occurred at Koshkonong on May 1, 1903, but not at Olden or at Doniphan; and a freeze occurred at Doniphan on May 2, 1909, but not at Koshkonong nor at Olden, etc. Such irregular occurrences of freezing temperatures in localities are probably the result of the position and direction of movement of the center of the high pressure area (anticyclone) with reference to the locality. The cold air spreads out and is drained away down to the southern slope of the Ozark Plateau, sometimes more toward the southwestward, then toward the south, and again the flow may affect only the southeast.

Table 2 gives the lowest temperatures of record and the lowest temperatures during the winter of 1909-1910, at the same stations:

TABLE 2.

County.	Station.	Lowest temperature ever recorded.	Date	Station.	Lowest temperature recorded during winter of 1909-1910.	Date.
		°F.			°F.	
McDonald.	Dean.	-25	Feb. 12, 1899	Dean.	-22	Feb. 18
Barry.	Mineral Springs	-28	Feb. 12, 1899	Hollister*	-16	Feb. 18
Taney.	Protem.	-17	Feb. 13, 1905	Olden.	-4	Feb. 18
Howell.	Olden.	-39	Feb. 12, 1899	Koshkonong.	0	Feb. 18
Oregon.	Koshkonong.	-16	Feb. 13, 1905	Doniphan.	-16	Feb. 18
Ripley.	Doniphan.	-9	Feb. 13, 1905			

\*In Taney County, about 22 miles northwest of Protem.

In the table showing the lowest temperatures ever recorded, it will be seen that it was colder at Koshkonong than at Doniphan on the same day, by 7°; but in the table to the right showing the coldest day during the winter of 1909-10, there is a noticeable difference, the higher temperatures being at Koshkonong and Olden. It appears as if the cold air current had divided, one part rolling toward the White River Valley, as indicated by the temperature at Hollister, and the other part going toward the Black River Valley as indicated by the temperature at Doniphan. Instead of the favorable peach belt, if any, extending east and west as suggested by Professor Howard, it probably extends northerly and southerly, or in other words, it lies along the Ozark border, a narrow strip of table land having elevations ranging between 500 and 1,000 feet, on which are situated Koshkonong, Mo., and Mammoth Springs, Hardy, and La Crosse, Ark. This strip bends not far from La Crosse and thence extends northwestward above the White River Valley. The temperature on this border does not fall so low at times as does that at lower as well as higher altitudes.

TABLE 3.

County.	Station.	Temperature.	Date.
		° F	
McDonald.	Dean.	28	Apr. 26
Taney.	Hollister.	31	Apr. 26
Howell.	Olden.	27	Apr. 25
Oregon.	Koshkonong.	29	Apr. 25
Ripley.	Doniphan.	32	Apr. 25

The cold of April 25 and 26, 1910, that caused so much damage to the fruit crop of Missouri, was quite uniformly distributed over the section under discussion, as may be seen from Table 3.

The cold spell was accompanied by cloudy skies and rain mixed with snow, and the movement of the cold currents of air was quite different from that which takes place under a clear sky, or when there is no rain or snow. It will be observed that during cold periods, with more or less cloudiness and moisture, the temperature on the hills may fall to a lower value than the temperature in the valleys; on the other hand, had clear weather prevailed during the nights of April 25 and 26, the temperature conditions would have been reversed, the valleys probably being much colder. It is also quite clear had the fruit in the valleys escaped winter injury it would have received no more damage from the freeze of April than was sustained in the neighborhood of Koshkonong.

The horticulturists at the University of Missouri have closely determined the temperatures representing the danger point to fruit for the different stages in its development, as shown by the following brief summary of Circular No. 13, Missouri Experiment Station, 1909:

Fully dormant peach buds can stand 8° or 9° below zero (F.). When they are appreciably swollen zero is the danger point. When the buds are showing pink they can stand 15° above zero. When the buds are almost open, 25° is the point of danger. When the petals are beginning to fall, 28° above zero is cold enough to cause uneasiness. When the petals are off they can stand 30° above zero. When the "shucks" (calyx tubes) are beginning to fall off 32° above zero is the danger point.

It is estimated that the April, 1910, freeze caused a loss to the people of Missouri of \$2,500,000, and it would mean thousands of dollars to the fruit growers in carrying out protective measures in the future to know just when to start the heaters in the orchards. It has been demonstrated that it is not a difficult matter, if one is prepared for it, and knows how to start the work, to raise the temperature in an orchard 5° to 6°, sufficient during almost any cold night in the spring to save many an orchard from injury. The question asked so often is, "When shall we start the heaters." To start them too soon is expensive; but to start them too late would be more expensive in the end. In this matter of advice, the Weather Bureau must shoulder the burden; and it must take up the task with an earnestness that should prove successful. The forecaster must be thoroughly familiar, not only with the geographical location and topographical conditions of the section for which forecasts are made, but he must keep himself fully informed as to the progress of the fruit crop in its different stages of advancement. The State forecast issued by the district forecaster is all that is necessary for the public in general, but where specific information is desired it is not satisfactory. It will not suffice to simply send a weather message to a fruit locality in time of danger from low temperature, reading "Fair to-night and colder, with frost;" but the message must say *how cold* it is expected to be; for instance something like the following, "Fair and colder to-night, with frost; temperature about 36°; no danger to fruit." And again, "Fair and colder to-night, with freezing temperature; 28° or lower by morning; start heaters after midnight."

While specifying the exact degree of cold expected may not be practicable for the district forecaster, owing to the extent of territory forecast for, and the limited time in which he has to make the forecast, it is being done, and can doubtless be brought to a high degree of accuracy, by the local forecasters.